(NASA-CR-141232) EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS. INITIAL EVALUATION TESTS OF GULTON INDUSTRIES, INCORPORATED 6.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS FOR THE SAN MARCO (Naval G3/44 N75-17788 Unclas 10269

EVALUATION PROGRAM for SECONDARY SPACECRAFT CELLS

INITIAL EVALUATION TESTS
OF
GULTON INDUSTRIES, INC.
6.0 AMPERE-HOUR, NICKEL-CADMIUM SPACECRAFT CELLS
FOR THE
SAN MARCO SPACECRAFT

prepared for
GODDARD SPACE FLIGHT CENTER
PURCHASE ORDER S-23404-G

WEAPONS QUALITY ENGINEERING CENTER

NAVAL AMMUNITION DEPOT, CRANE, INDIANA

DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
WEAPONS QUALITY ENGINEERING CENTER
CRANE, INDIANA 47522

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Enclosure (1)

REPORT BRIEF
INITIAL EVALUATION TESTS
OF
GULTON INDUSTRIES, INCORPORATED
6.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
FOR THE
SAN MARCO SPACECRAFT

Ref: (a) NASA Purchase Order S-23404-G
(b) Initial Evaluation Test Procedure for Nickel-Cadmium Sealed Space Cells: NADC 3053-TP324 of 10 Apr 73

I. TEST ASSIGNMENT BRIEF

A. The purpose of this evaluation test program is to insure that all cells put into the life cycle program are of high quality by the screening of cells found to have electrolyte leakage, internal shorts, low capacity, or inability of any cell to recover its open-circuit voltage above 1.150 volts during the internal short test.

B. The 10 cells were purchased by the National Aeronautics and Space Administration, Goddard Space Flight Center, under LTV Purchase Order Number 833219. They were manufactured to Goddard Space Flight Center's specification number S-761-P-6 with waivers given to the ratio requirement of paragraph 3.4.3.2.7.3 and the particle size requirement of paragraph 3.4.3.2.1.2.1. Plates had heavier loading of active material. Five of the cells have a higher amount of electrolyte than the other five cells. All the cells are rated at 6.0 ampere-hours, contain double ceramic seals, and were fitted with pressure gauge assemblies prior to testing. Testing was funded in accordance with reference (a).

C. Test limits specify those values in which a cell is to be terminated from a particular charge or discharge. Requirements are referred to as normally expected values based on past performance of aerospace nickel-cadmium cells with demonstrated life characteristics. A requirement does not constitute a limit for discontinuance from test.

II. SUMMARY OF RESULTS

A. The five cells with the higher amount of electrolyte normally exhibited higher end-of-charge voltages and pressures during test.

B. One cell, S/N 1096, which had the lower amount of electrolyte, did exhibit much higher end-of-charge pressures than other cells with the lower amount of electrolyte. It also was the only cell to exceed the pressure requirement of 65 psia during the 35° C overcharge test.

C. The cell containers had a convex contour, in which the average thickness of the cells was 0.009 inch thicker at the maximum thickness when compared to the minimum thickness, which was the edge of the container. Following test, this value was 0.010 inch indicating an increase in the plate stack thickness although some cells did decrease in thickness.

D. All cells exceeded the voltage requirement of 1.480 volts during the charge portion of the third capacity test.

E. During the charge portion of the charge retention test, three cells with the higher amount of electrolyte, and one with the lower, exceeded the pressure limit of 100 psia. The average cell voltage at the end of 1 week open-circuit was 1.304 volts and average capacity output was 7.1 ampere-hours following this stand period.

F. Five cells, three with the lower amount of electrolyte, failed to deliver 55 percent of capacity input during discharge of the charge efficiency test. The cells with the lower amount of electrolyte had higher end-of-charge voltages than the other cells.

G. All cells exceeded the voltage requirement of 1.520 volts during the 0° C overcharge test. Of the cells with the higher amount of electrolyte; three were removed from charge due to high pressure (100 psia), one was removed due to high cell voltage, and the other exceeded the pressure requirement of 65 psia. One cell, S/N 1096, with the lower amount of electrolyte, also exceeded 65 psia.

H. During the pressure versus capacity test; (1) Cell S/N's 1063, 1090, 1100 and 1106 reached the pressure limit of 20 psia before reaching their voltage limit of 1.550 volts, (2) cell S/N's 1096 and 1116 reached 1.550 volts before reaching 20 psia, and, (3) cells S/N's 1092, 1102, 1104 and 1109 reached 20 psia with a voltage of 1.550. Two cells, with the lower amount of electrolyte, exhibited a pressure decay of 2 psia during the last 30 minutes of the 1-hour open-circuit stand. Average capacity out was 8.4 ampere-hours.

III. RECOMMENDATIONS

A. Manufacturing processes and controls should be such to prevent swelling of the plate stack, thereby preventing cell case distortion.

B. It is recommended that these cells be placed into the life cycling program simulating that which the flight batteries will experience in orbit and also for comparison of performance between the cells with the different amounts of electrolyte.

C. On 25 September 1974, this 10-cell battery (Pack 6M) began life-cycle test.

RESULTS OF INITIAL EVALUATION TESTS OF GULTON INDUSTRIES, INCORPORATED 6.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS FOR THE SAN MARCO SPACECRAFT

I. TEST CONDITIONS AND PROCEDURE

A. All evaluation tests were performed at room ambient (RA) pressure and temperature (25° ± 2° C), with discharges at the 2-hour rate, and in accordance with reference (b), unless otherwise specified, and consisted of the following:

1. Phenolphthalein leak tests (2).

2. Three capacity tests, third at 20° C, with internal resistance measurements during second charge/discharge.

3. Charge retention test, 20° C.

4. Internal short test.

5. Charge efficiency test, 20° C.

6. Overcharge tests, 0° and 35° C.

7. Pressure versus capacity test.

8. Phelolphthalein leak test.

(See Appendix I for summary of test procedure.)

II. CELL IDENTIFICATION AND DESCRIPTION

A. These cells exhibited out-of-specification pressures during electrical testing by the manufacturer. The manufacturer proceeded to "rework" the cells by spinning a centrifuge to reduce the amount of electrolyte (KOH). Varying amounts of KOH were removed from these cells, using weight loss as the criteria, then one cubic centimeter (cc) was added to each cell. Prior to shipment, four cubic centimeters were added to each of five cells, and these are referred to as the cells with the higher level of electrolyte. The cells were identified by the manufacturer as Model V06HS, Part No. 804596, with serial numbers and final KOH quantity as follows:

CELL S/N	KOH (cc)	CELL S/N	KOH (cc)
1063	17.5	1102	14.2
1090	13.8	1104	13.6
1092	17.8	1106	17.3
1096	13.6	1109	13.0
1100	18.0	1116	17.7

The cells were fitted with pressure gauge assemblies and placed in a pack configuration for testing (Pack 6M).

B. The 6.0 ampere-hour cell is rectangular with an average weight and physical dimensions as follows:

Weight (g)	Overall Height (In)	Length (In) Minimum	Length (In) Pre-Test Max	Length (In) Post-Test Max	Width (In)
683.5	3.708	0.826	0.835	0.836	2.098

Individual cell measurements are listed in Table I.

C. The cell containers and covers are made of stainless steel. The positive and negative terminals are insulated from the cell cover by ceramic seals and protrude through the cover as solder type terminals.

III. RESULTS--THE FOLLOWING WAS CONDENSED FROM TABLES I THROUGH VI.

A. The five cells with the higher amount of electrolyte exhibited higher end-of-charge voltages and pressures during test except during the charge efficiency test.

B. One cell, S/N 1096, which had the lower amount of electrolyte, did exhibit much higher end-of-charge pressures than other cells with the lower amount of electrolyte.

C. The cell containers had a convex contour, in which the average thickness of the cells was 0.009 inch thicker at the maximum thickness when compared to the minimum thickness, which was the edge of the container. Following test, this value was 0.010 inch indicating an increase in the plate stack thickness although some cells did decrease in thickness.

D. There were differences in the average end-of-charge (EOC) voltages and capacity output in ampere-hours (ah), between the five cells with the lower amounts of KOH and those with the higher amounts. Following is a listing of these averages:

	VOLTS		AH OUT	
CHARGE	LOW KOH	HIGH KOH	LOW KOH	HIGH KOH
c/20 for 48 hours at 25° C	1.438	1.441	8.5	8.5
c/10 for 24 hours at 25° C	1.439	1.450	8.4	8.6
c/10 for 24 hours at 20° C	1.472	1.479	8.1	8.4
c/10 for 24 hours at 20° C*	1.462	1.467	7.0	7.1
c/40 for 20 hours at 20° C**	1.364	1.362	1.3	1.4
c/20 for 60 hours at 0° C	1.535	1.549	7.7	7.8
c/10 for 24 hours at 35° C	1.379	1.386	6.1	7.2

*Charge retention test.

**Charge efficiency test, 2.45 ah input.

E. Average Internal Resistance Measurements (milliohms):

MEASUREMENTS TAKEN	RESISTANCE
30 Min before end of charge (Cycle 1)	3.48
1 Hr after start of discharge (Cycle 2)	3.87
2 Hrs after start of discharge (Cycle 2)	3.86

F. All cells exceeded the voltage requirement of 1.480 volts during the charge portion of the third capacity test.

G. During the charge portion of the charge retention test, three cells with the higher amount of KOH, and one with the lower, exceeded the pressure limit of 100 psia. The average cell voltage at the end of 1 week open-circuit, during this test, was 1.304 volts.

H. The 24-hour average cell voltage following a 16-hour short period, was 1.234 volts.

I. Five cells, three with the lower amount of electrolyte, failed to deliver 55 percent of capacity input during discharge of the charge efficiency test.

J. All cells exceeded the voltage requirement of 1.520 volts during the 0° C overcharge test. Of the cells with the higher amount of electrolyte; three were removed from charge due to high pressure, one was removed due to high cell voltage, and the other exceeded the pressure requirement of 65 psia. One cell, S/N 1096, with the lower amount of electrolyte, also exceeded 65 psia.

K. Cell, S/N 1096, exceeded the pressure requirement of 65 psia during the 35° C overcharge test.

L. During the pressure versus capacity test; (1) Cell S/N's 1063, 1090, 1100 and 1106 reached the pressure limit of 20 psia before reaching their voltage limit of 1.550 volts, (2) cell S/N's 1096 and 1116 reached 1.550 volts before reaching 20 psia, and (3) cells S/N's 1092, 1102, 1104 and 1109 reached 20 psia with a voltage of 1.550. Two cells, with the lower amount of electrolyte, exhibited a pressure decay of 2 psia during the last 30 minutes of the 1-hour open-circuit stand. Average capacity out was 8.4 ampere-hours.

APPENDIX I

APPENDIX I

I. TEST PROCEDURE

A. Phenolphthalein Leak Tests:

1. This test is a determination of the condition of the welds and ceramic seals on receipt of the cells and following the last discharge of the cells (Cycle #8).

2. The cells were initially checked with a one-half of one percent phenolphthalein solution applied with a cotton swab and then placed in a vacuum chamber and exposed to a vacuum of 40 microns of mercury or less for 24 hours. Upon removal they were rechecked for leaks and then received a final check following test completion. The requirement is no red or pink discoloration which indicates a leak.

B. Capacity Tests:

1. The capacity test is a determination of the cells' capacity at the c/2 discharge rate to 0.75 volts per cell, where c is the manufacturer's rated capacity. This type discharge follows all charges of this evaluation test.

2. The charges for the capacity tests are as follows:

a. c/20, 48 hours, room ambient (RA), cycle 0, with a test limit of 1.52 volts or pressure of 100 psia.

b. c/10, 24 hours, RA, cycle 1, with a test limit of 1.52 volts or 100 psia pressure and a requirement of maximum voltage (1.48) or pressure (65 psia).

c. c/10, 24 hours, 20° C, cycle 2, with the same limits and requirements as the charge of cycle 1.

C. Internal Resistance:

1. Measurements are taken across the cell terminals 1/2 hour before the end-of-charge (EOC) on cycle 1; and 1 and 2 hours after the start of discharge of cycle 2. These measurements were made with a Hewlett-Packard milliohmmeter (Model 4328A).

D. Special Charge Retention Test, 20° C:

1. This test is to establish the capacity retention of each cell following a 7-day open-circuit stand in a charged mode.

2. The cells are charged at c/10 for 24 hours with a test limit of 1.52 volts or 100 psia pressure. They then stand on open-circuit for 7 days, with the requirement that the open-circuit voltage of each cell, following this period, is within $\pm$ 5 millivolts of the average cell voltage. The cells are then discharged and 90 percent capacity out of that obtained in cycle 3 is required.

E. Internal Short Test:

1. This test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, or damage to the element in handling or assembly.

2. Following completion of the third capacity discharge, the cells are shunted with a 0.5-ohm, 3-watt resistor for 16 hours. At the end of 16 hours the resistors are removed and the cells stand on open-circuit voltage (OCV) for 24 hours. A minimum voltage of 1.15 is required at the end of 24 hours.

F. Charge Efficiency Test, 20° C:

1. This test is a measurement of the cells' charge efficiency when charged at a low current rate.

2. The cells are charged at c/40 for 20 hours with a test limit of 1.52 volts or 100 psia pressure. They are then discharged and the requirement is that the minimum capacity out equals 55 percent of capacity in during the preceding charge.

G. Overcharge Test #1, 0° C:

1. The purpose of this test is to determine the degree to which the cells will maintain a balanced voltage, and to determine the cells' capability to be overcharged without overcharging the negative electrode.

2. The cells are charged at c/20 for 60 hours. The test limits are cell voltages of 1.56 or greater for a continuous time period of 2 hours or pressures of 100 psia. The requirement is a voltage of 1.520 or a pressure of 65 psia. The cells are then discharged and 85 percent capacity out of that obtained in cycle 3 is required.

H. Overcharge Test #2, 35° C:

1. This test is a measurement of the cells' capacity at a higher temperature when compared to its capacity at 20° C. This test also determines the cells' capability of reaching a point of pressure equilibrium; oxygen recombination at the negative plate at the same rate it is being generated at the positive plate.

2. The cells are charged at c/10 for 24 hours with a test limit of 1.52 volts or 100 psia pressure and a requirement of 1.45 volts or 65 psia pressure. The cells are then discharged with a requirement that capacity out equals 55 percent capacity out as obtained in cycle 3.

I. Pressure Versus Capacity Test:

1. The purpose of this test is to determine the capacity to a pressure and the pressure decay during charge and open circuit stand respectively.

2. Each cell is charged at c/2 to either a pressure of 20 psia or a voltage of 1.550. Recordings are taken on each cell when it reaches 5, 10, 15 and 20 psia pressure. The cells then stand OCV for 1 hour with 30-minute recordings and then are discharged, shorted out and leak tested.

TABLE I
MEASUREMENT AND LEAK TEST DATA

SERIAL NUMBER	WEIGHT (Grams)	HEIGHT (Inches)	LENGTH (Inches)			WIDTH (Inches)	PHENOLPHTHALEIN LEAK TESTS								
							INITIAL			POST HI VAC			POST TEST		
							Terminals		Other	Terminals		Other	Terminals		Other
			MINIMUM	MAXIMUM (Pre-Test)	MAXIMUM (Post-Test)		+	-		+	-		+	-	
1063	683.3	3.710	.830	.836	.832	2.100									
1090	695.1	3.692	.819	.835	.832	2.092									
1092	683.9	3.716	.820	.840	.840	2.094	NO	LEAKS							
1096	683.5	3.714	.826	.835	.837	2.100									
1100	686.1	3.700	.830	.830	.836	2.110				NO	LEAKS				
1102	680.6	3.712	.828	.835	.836	2.095									
1104	679.4	3.700	.830	.832	.836	2.095							NO	LEAKS	
1106	684.1	3.714	.817	.836	.838	2.096									
1109	679.2	3.715	.827	.836	.835	2.096									
1116	679.4	3.702	.830	.837	.834	2.104									

TABLE II
CAPACITY DATA

SERIAL NUMBER	CAPACITY TEST 1						CAPACITY TEST 2						CAPACITY TEST 3 (20°C)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL* (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
1063	1.440	N/A	71	8.4	N/A	36	1.450	N/A	92	8.5	N/A	60	1.478	N/A	88	8.3	N/A	63
1090	1.437	N/A	24	8.4	N/A	4	1.439	N/A	55	8.2	N/A	7	1.476	N/A	59	7.9	N/A	17
1092	1.441	N/A	49	8.5	N/A	21	1.448	N/A	78	8.6	N/A	45	1.481	N/A	71	8.4	N/A	49
1096	1.441	N/A	53	8.5	N/A	19	1.447	N/A	82	8.5	N/A	43	1.479	N/A	75	8.2	N/A	47
1100	1.438	N/A	67	8.5	N/A	37	1.448	N/A	88	8.6	N/A	59	1.478	N/A	87	8.3	N/A	64
1102	1.438	N/A	14	8.4	N/A	6	1.436	N/A	22	8.3	N/A	4	1.469	N/A	31	8.1	N/A	6
1104	1.435	N/A	12	8.3	N/A	5	1.436	N/A	23	8.3	N/A	3	1.464	N/A	35	8.0	N/A	5
1106	1.438	N/A	65	8.5	N/A	35	1.446	N/A	89	8.6	N/A	52	1.473	N/A	87	8.3	N/A	60
1109	1.438	N/A	15	8.7	N/A	5	1.437	N/A	31	8.5	N/A	5	1.474	N/A	51	8.2	N/A	13
1116	1.446	N/A	62	8.7	N/A	27	1.456	N/A	77	8.6	N/A	40	1.486	N/A	88	8.5	N/A	60

* - All cells exceeded 1.480 volts during charge.

TABLE III
INTERNAL RESISTANCE AND SHORT TEST DATA

SERIAL NUMBER	INTERNAL RESISTANCE (MILLIOHMS)			INTERNAL SHORT TEST		
	END-OF-CHARGE	ONE HOUR AFTER START-OF-DISCHARGE	TWO HOURS AFTER START-OF-DISCHARGE	AFTER 16 HR SHORT	AFTER 24 HOUR OCV STAND	
				CELL	CELL	PRESS
1063	3.6	3.6	3.5	.031	1.232	5
1090	4.4	4.4	4.3	.032	1.244	1
1092	4.0	4.0	4.0	.034	1.240	5
1096	4.0	4.1	4.0	.035	1.237	4
1100	3.6	3.4	3.4	.033	1.233	4
1102	4.0	4.0	4.1	.019	1.229	3
1104	3.8	4.0	4.0	.020	1.229	2
1106	3.4	3.5	3.4	.020	1.227	6
1109	4.0	3.9	4.0	.031	1.237	2
1116	3.8	3.8	3.9	.030	1.235	8

TABLE IV
CHARGE RETENTION TEST DATA

SERIAL NUMBER	END-OF-CHARGE			24 HR. OCV			1 WEEK OCV			END-OF-DISCHARGE		
	CELL (VOLTS)	AUX. ELECT. (VOLTS)	PRESS. (PSIA)	CELL (VOLTS)	AUX. ELECT. (VOLTS)	PRESS. (PSIA)	CELL (VOLTS)	AUX. ELECT (VOLTS)	PRESS. (PSIA)	CAPACITY (AH)	AUX. ELECT. (VOLTS)	PRESS. (PSIA)
1063	1.465	N/A	102*	1.340	N/A	23	1.305	N/A	5	7.1	N/A	5
1090	1.460	N/A	69	1.337	N/A	3	1.302	N/A	1	6.9	N/A	1
1092	1.469	N/A	98■	1.339	N/A	21	1.305	N/A	6	7.0	N/A	6
1096	1.467	N/A	94■	1.337	N/A	20	1.303	N/A	5	6.9	N/A	5
1100	1.463	N/A	102*	1.338	N/A	37	1.305	N/A	5	7.1	N/A	5
1102	1.460	N/A	44■	1.339	N/A	6	1.302	N/A	3	7.1	N/A	3
1104	1.458	N/A	48■	1.339	N/A	5	1.302	N/A	3	7.1	N/A	3
1106	1.464	N/A	101*	1.340	N/A	22	1.304	N/A	6	7.2	N/A	6
1109	1.464	N/A	60■	1.339	N/A	5	1.303	N/A	3	7.2	N/A	3
1116	1.472	N/A	100*■	1.340	N/A	25	1.305	N/A	9	7.2	N/A	9

* - Removed from charge due to High Pressure - AH_{in} = Cells 2,5,10 (12.1), Cell 8 (12.4)

■ - Exceeded 1.480 volts during charge

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TABLE V
Charge Efficiency and Overcharge Data

SERIAL NUMBER	Charge Efficiency (20°C)						Overcharge Test (0°C)						Overcharge Test (35°C)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
1063	1.362	N/A	5	1.5	N/A	5	1.552	N/A	100*	7.8	N/A	79	1.390	N/A	63	7.4	N/A	57
1090	1.365	N/A	1	1.3	N/A	1	1.522	N/A	39	7.3	N/A	18	1.378	N/A	51	5.9	N/A	14
1092	1.362	N/A	6	1.5	N/A	6	1.514	N/A	75	8.1	N/A	59	1.383	N/A	51	6.8	N/A	36
1096	1.362	N/A	5	1.5	N/A	6	1.520	N/A	71	7.8	N/A	54	1.384	N/A	80	6.7	N/A	52
1100	1.361	N/A	5	1.5	N/A	5	1.552	N/A	101*	7.6	N/A	63	1.386	N/A	58	7.3	N/A	47
1102	1.366	N/A	4	1.2	N/A	4	1.552	N/A	23	8.0	N/A	13	1.378	N/A	37	5.9	N/A	9
1104	1.365	N/A	2	1.5	N/A	2	1.548	N/A	27	7.9	N/A	15	1.378	N/A	34	6.0	N/A	7
1106	1.361	N/A	6	1.3	N/A	6	1.555	N/A	103*	7.7	N/A	61	1.386	N/A	59	7.3	N/A	46
1109	1.364	N/A	2	1.2	N/A	2	1.531	N/A	28	7.6	N/A	14	1.377	N/A	55	6.0	N/A	17
1116	1.362	N/A	8	1.2	N/A	8	1.574**	N/A	70	7.9	N/A	39	1.387	N/A	57	7.3	N/A	43

* - Removed from charge due to High Pressure, AH_{in} = Cell 1 (11.6), Cell 5 (11.9), Cell 8 (11.9)

** - Removed from charge due to High Cell Voltage, AH_{in} = 11.1

TABLE VI
PRESSURE VS. CAPACITY TEST DATA

Serial No.	1063	1090	1092	1096	1100	1102	1104	1106	1109	1116
Start-of-Charge, Press.	4	4	2	4	4	5	4	4	4	2
AH in to 5 PSIA	9.0	8.4	9.5	9.3	8.4		7.0	8.4	7.0	9.5
Cell (volts)	1.453	1.460	1.473	1.466	1.440		1.437	1.440	1.438	1.482
Aux (volts)	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A
AH in to 10 PSIA	10.2	10.2	10.3	10.5	10.2	9.6	9.6	10.2	10.2	10.2
Cell (volts)	1.517	1.533	1.521	1.543	1.513	1.530	1.520	1.512	1.528	1.538
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AH in to 15 PSIA	10.3	10.3	10.6	10.6	10.3	10.0	10.0	10.4	10.5	
Cell (volts)	1.534	1.546	1.539	1.557	1.530	1.572	1.559	1.533	1.555	
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
AH in to 20 PSIA	10.6	10.4	10.8		10.6	10.0	10.0	10.5	10.6	
Cell (volts)	1.548	1.548	1.552		1.545	1.572	1.563	1.543	1.557	
Aux (volts)	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	
AH in to V/L (1.55V)			10.8	10.6		10.6	10.0		10.6	10.3
Aux (volts)			N/A	N/A		N/A	N/A		N/A	N/A
Press (PSIA)			21	15		15	15		20	12
30 Min OCV, Cell	1.392	1.385	1.392	1.390	1.389	1.376	1.378	1.390	1.386	1.389
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Press (PSIA)	30	20	26	18	30	15	15	26	19	15
1 hour OCV, Cell	1.382	1.375	1.381	1.380	1.379	1.370	1.371	1.380	1.376	1.381
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Press (PSIA)	30	20	26	19	30	15	13	27	17	15
EOD AH out	8.5	8.4	8.6	8.5	8.5	8.2	8.1	8.5	8.5	8.5
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Press (PSIA)	23	7	17	12	23	8	7	19	7	11

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